Findings on supply

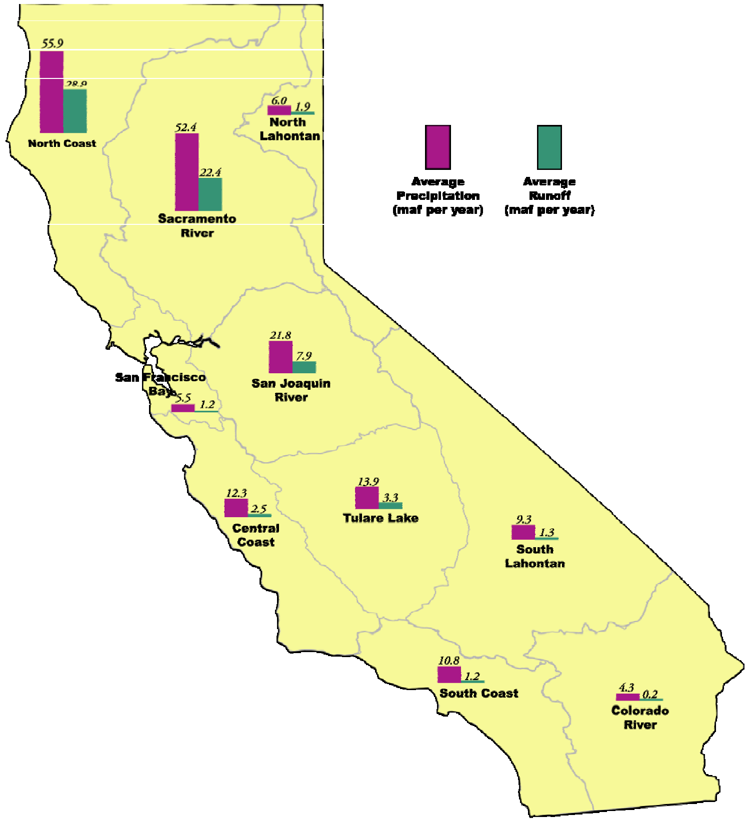
Historic value

An ancient Chinese proverb says, "*To rule the mountain is to rule the river.*" In 1886, the American Forestry Congress adopted a resolution concerning the value of having public lands at the source of water supplies "with a view to maintaining and preserving a full supply of water in all rivers and streams." California followed this concern in 1888 when the State legislature asked Congress to stop disposing federal lands within the state and to preserve them permanently for protection of watersheds. The Sierra Forest Reserve (now Sequoia National Forest) was set aside from the public domain in 1893 at the request of San Joaquin Valley farmers to protect their water supply from threats by upstream mining, grazing, and lumbering interests (Dilsaver and Tweed, 1990). When Congress finally enacted the Organic Administration Act for national forests in 1897, one of the principal purposes of the forests was for the "securing of favorable conditions of water flows."

California's water origins and sources (see DWR Bulletin 160–98)

Water comes from precipitation in the form of rainfall or snow, with California averaging 23 inches annually or approximately 200 million acre-feet (maf). After evaporation and transpiration by trees and other plants, 35 percent of this precipitation emerges as surface water runoff (Figure 3). A significant amount of California's surface runoff is derived from forested areas. Exactly how much varies according to how the estimate is made.

Figure 3. Average annual precipitation and runoff (million acres-feet per year)



Source: Department of Water Resources, 1998

A recent report on the role of the U.S. Forest Service (USFS) and water uses a runoff estimate based on the Mapped Atmosphere Plant-Soil-System (MAPSS) model (USFS, 2000). Nationally, approximately two-thirds of runoff comes from forested areas, with national forest lands yielding about 14 percent of the runoff. For California, national forest lands represent 20 percent of the State's land area but contribute about 45 percent of the State's total runoff or 33 maf per year. National forests in the State cover most of the major mountain ranges and headwaters from the Six Rivers, Klamath, and Modoc national forests in the north to the Angeles and San Bernardino forests in the south. Some of this runoff amount also recharges groundwater basins. For complete information on the USFS report on water, see Water and the Forest Service.

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Water for the State Water Project (SWP), with its 22 dams and 600 miles of canals, originates mainly on Sierra Nevada national forest lands. The Sierra Nevada national forests yield more than two million acre-feet annually to 20 million urban and agricultural users in the San Francisco Bay Area and southern California (Water Education Foundation, 1995). The federal Central Valley Project (CVP), with 20 reservoirs and more than 500 miles of canals, depends on seven million acre-feet of water from Forest Service lands to irrigate three million acres of Central Valley farmland and provide drinking water to two million people (Water Education Foundation, 1995). Many of the large cities in California rely on national forest system watersheds including Eureka, Oakland, Berkeley, Fresno, and Los Angeles. Yosemite National Park lands yield water to San Francisco.

Cycles and timing of water

Seasonal and annual variability are part of California's water landscape. Three-fourths of the State's average annual precipitation occurs between November and March. Dry and wet water cycles are a continuous feature. During the last century, the most extreme wet water year was 1982-83 and the most extremely dry water year was 1923-24 or 1976-77. There were also many notable extremes. The January 1997 floods were the largest and most extensive flood disaster in California's history but were followed by a record setting six-month dry period. The six-year drought from 1987-1992 was preceded by the record setting 1986 floods (Department of Water Resources, 1998). The 2001 drought equaled or exceeded previous droughts in the northern most region of the State.

Seasonal water storage from snow precipitation in the Sierra Nevada.

Floods and flood management

Water runoff can also be excessive, with a major timing issue being flooding—too much water in a short amount of time. California has long applied flood control practices in the attempt to protect property and lives from damaging floods. Major flood events of the past century fomented State and local flood management policies, sometimes ahead of the fundamental information base needed to design successful solutions (Kelley, 1989). An extensive system of flood control dams and levees exists throughout flood prone areas of the State. While most Central Valley flood control projects were originally designed to protect farms and farmers, these projects must now also protect large urbanized metropolitan areas and their residential, commercial, and public buildings. Almost two million people live in the Sacramento Valley floodplain.

Although water year 1983 was the wettest of the twentieth century in California, no major flooding occurred. The floods of February 1986 and January 1997 were the largest and most extensive flood disasters of recent times. Channel capacities were exceeded with flood flows by as much as 700 percent (Department of Water Resources 1998). While major flood control dams were able to reduce peak flows, some leveed flood control systems were overwhelmed. In the 1997 flood, over 300 square miles were under water, 120,000 people were forced to flee, nine people died, and two billion dollars in property damage resulted.

Floodplain management seeks to use flood hazard maps and federal insurance as a means of reducing risk from flooding; however, with changes in hydrology and development, the 100–year floodplain concept does not reflect the actual flood risk and can provide a false sense of security for development within floodplains (Mount, 1995). Urbanization alters the timing and pattern of runoff, since roads, paved parking lots, and storm drains move water downhill faster than natural slopes. As a result, a larger amount of runoff discharges into streams during a shorter period of time. The flood peaks tend to increase in channels carrying urban runoff (Leopold, 1994).


Downstream flooding.

There is a growing movement to change "flood control" into "flood management" where the goal becomes working with, rather than against rivers and creeks (Mount, 1995; Riley, 1998). Instead of stream channelization, for example, knowledge about the dynamics of natural and urban streams in general and the specific stream in particular should be used to preserve as many aspects of the channel's geomorphic diversity. Levees can be moved away from the rivers to allow channels to meander and allow more storage on the floodplain. Detention wetlands and revegetation of bare or impervious surfaces will help infiltration and reduce runoff peaks. The University of California at Berkeley emeritus professor of hydrology, Dr. Luna Leopold, advocates that "flood control" should place much greater emphasis on restriction of development of floodplains, flood proofing of individual sites or local areas, an insurance program in which premiums are proportional to risk, and planned use of floodplains for peak flow reduction (Leopold, 1994).

Supply versus demand

The supply of water was insufficient to meet demand for water in 1995 and is projected to be insufficient in 2020, especially during a drought year. Statewide, the imbalance is exacerbated by population growth, with the State's population expected to grow from 32.1 million in 1995 to 46 million in 2020, an increase of over 43 percent. Agricultural water use is expected to decline due to the conversion of farmland to urban use.

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Table 2. Statewide water budget for year 2020 with existing facilities and programs (million acre-feet)

	2020 – average water year	**2020 – drought water year**
Water use	80.5	66.0
Water supplies		
Surface water	65.0	43.4
Groundwater	12.7	16.0
Recycled and desalted	0.4	0.4
Total	78.1	59.8
Shortage	–2.4	–6.2

Source: Department of Water Resources, 1998

Balancing needs of water use and supply

The *California Water Plan* (Department of Water Resources, 1998) identifies the many efforts being attempted to better balance water use and supply. As noted above, the future water supply reliability is in doubt for average water years but especially during drought years. Imbalances also vary from region to region within the State, with areas of rapid population growth showing the greatest need. The strategy to address the imbalance involves both demand reduction as well as water supply augmentation options.

Urban water conservation is applied at the local level through actions of water purveyors and individual users. Since the 1976–77 drought, significant reductions in per capita water use have occurred throughout the State. More than 200 urban water suppliers have signed the 1991 Memorandum of Understanding Regarding Urban Water Conservation in California (MOU). Implementation of urban best management practices (BMPs) described in the MOU (as revised) for residential, commercial, industrial, and institutional uses of water are now assumed in calculating water demand forecasts. Such conservation measures include increasing the water use efficiency of plumbing fixtures, performing water audits and leak detection programs, adopting water efficient landscape ordinances, and setting conservation pricing. Urban BMPs are expected to reduce demand by 1.5 maf by 2020.

Agricultural water conservation depends upon the actions of both water suppliers and irrigation water users. High water use efficiency on a farm is achieved through irrigation management, irrigation methods, crop selection, and supply reliability. Efficient Water Management Practices (EWMPs) for agricultural water use are identified and promoted through a 1996 MOU and the Agricultural Water Management Council. In addition, water agencies contracting with the U.S. Bureau of Reclamation are required to adopt water conservation plans and have water measurement devices. Agricultural water conservation is estimated to reduce applied water demands by about 800 thousand acre-feet (taf) by 2020 but because of less reuse and deep percolation to ground water, reductions in net water demand will be much less than this figure (Department of Water Resources, 1998).

In the past decade, state and regional water supplies were partially augmented by several large dams and some major water conveyance projects but not enough to meet current dry year or future demands. Most of the statewide water supply planning is now being carried out for the CALFED Bay-Delta program (see CALFED) or for the State Water Project (SWP) future supply. Strategy involves developing additional surface storage facilities, exploring conjunctive use of groundwater storage areas, water recycling and desalting, water marketing, and weather modification. The Sacramento River basin represents the most potential for additional water development to meet statewide demands, according to DWR. Current storage proposals focus on enlarging Shasta Dam, studying a new westside off-stream reservoir known as Sites Dam, enlarging Los Vaqueros Reservoir south of the Delta, and studying the enlargement of Millerton Lake at Friant Dam in the San Joaquin Valley, among other ideas. As common with California's complex water issues, strong reactions resulted from these recent proposals by CALFED and none of the proposed solutions are certain (Hundley, 2001).

Findings on water valuation

The economic importance of water to the State cannot be understated. The ability for water supply regeneration through seasonal precipitation makes it a reliable and useful commodity. The State's massive storage and diversion projects have supplied municipal and industrial growth in areas far from the water origin (mountain areas). Also, productive agricultural centers have been created by the water projects.


Flood gates

Water is not valued as a typical commodity, where demand and supply operate to determine the going price (Kahrl, 1979). Water is a public resource that was largely developed by public agencies and as such, the public is both buyer and seller of the water. The prices of agricultural and urban water depend not just on the original costs of development or the annual treatment, maintenance, pumping and energy costs, but also upon our willingness and ability to pay, regional differences, legal constraints, regulations, and competing environmental and economic interest groups.

Water pricing systems in California do not necessarily assign a scarcity value to water, but change has begun by some suppliers during drought years. In extremely dry years, the greater competition for water has increased the market value for leasing from about \$60-\$70 per acre-foot to \$100-\$125 per acre-foot and as high as \$300, depending on the location and type of water (Newcom, 2001).

Dam and reservoir. Photo courtesy of Department of Water Resources.

Water users have become accustomed to receiving relatively cheap water out of their taps, with water historically being under priced and even subsidized to make it affordable for everyone. On the other hand, the use of more expensive bottled drinking water has increased in the State due to consumer taste preference, concern over possible health effects of public water treatment, and convenience. In addition, health and nutrition experts recommend drinking eight or more eight–ounce servings of water daily. In 1999, California consumed 1.1 billion gallons (3.5 taf) of bottled water or 22.9 gallons per person per year, representing an increase of 28 percent since 1994 (Beverage Marketing Corp., 2000). Residents of Los Angeles and San Diego drink the most bottled water (3.2 servings) of 14 national cities recently surveyed and consume the most bottled and tap water overall (6.9 and 6.4 servings per day) (International Bottled Water Assoc., 2002). Bottled water can come from any bottled water plant within the State, nation, or world and cannot be tracked as an imported water source. However, the total amount remains quite small (less than .1% 0f total urban uses) in comparison to total water consumption in the State.

With greater competition for urban water sources in this rapidly growing state, the cost of drinking water is increasing and previously rejected supply alternatives are being reevaluated. Seawater desalination plants are being seriously considered to supplement the water supply in densely populated, south coastal California. New technology has increased the efficiency and lowered the cost of desalting ocean water, though high energy costs of treatment can still be an impediment, according to the Metropolitan Water District of Southern California. Recycled (reclaimed) water is becoming more acceptable socially and financially, as well as environmentally, as new wastewater filtration treatment systems provide a higher quality product. These alternative sources can now be used because the value of urban water has increased to make them relatively affordable.

In-stream values of water can be quite significant and tend to be sensitive to water quality.

Environmental uses of water—in-stream flows, recreation, aquatic habitat, wild and scenic rivers—do not have a tangible value that can be readily assigned through the market. Intangible values of an environmental asset involve user values (such as by users of water-based recreation) and nonuser values (Gibbons, 1986). Nonuser values are often estimated by what the public is willing to pay for the non-use of water.

In–stream values of water can be quite significant and tend to be sensitive to water quality, especially when calculating the benefits of water quality improvement for the users of water-based recreation. Although in-stream values have beneficial uses assigned to them by the SWRCB, they still do not provide a clear mechanism for carrying quantifiable weight in the setting of water prices. As a result, the water price of the existing water supply usually remains underestimated. In addition, the full or true cost of developing new water supplies is not reflected in the new price the agricultural or urban water user will be paying (Kahrl, 1979).

Water value from forest and range lands

In California, national forests produce about 33.2 million acre feet of in-stream flow and 9.5 million acre feet for off-stream use (e.g., diverted into irrigation canals, municipal storage) (U.S. Forest Service, 2000). The Forest Service estimates that the annual value of water from its lands in California at almost one billion dollars, based on values of withdrawal to off-stream use at $40 per acre-foot. Forest Service values for in-stream flow are $17 per acre-foot (e.g., hydroelectric power and recreation). This estimate shows the high value and relative importance of national forest lands, even though it understates the true value of water flowing from them.

These values do not include the non-use values mentioned above, nor the values of waste dilution, channel maintenance, aquatic habitat and wetland functions, nor the average value (only the marginal value of our willingness to pay for a change in the amount of water). As such, the nearly one billion dollars worth of water from California's national forests represents the minimum value of that water runoff to society.

Economic value derived from water in the Sierra Nevada bioregion

Assessing the economic benefits of different types of water diversions was recently done for the Sierra Nevada region (Stewart, 1996). Of the various uses, the most valuable for revenue generation is electrical generation by hydropower plants. An average of 40 million acre-feet run through the turbines yearly. Water used for hydroelectric production is non-consumptive and reused downstream by consumptive users, both irrigation and municipal.

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Supplemental, but less tangible, values are also attributed to in-stream uses, such as water-based recreation (e.g., fishing, white water rafting) and water-dependent ecosystems (e.g., wetlands, riparian habitats). The estimated economic value of all these water diversions represents the largest single commodity produced from the Sierra Nevada ecosystem. Assigning dollar values to the various uses, based on certain assumptions, allows an estimated annual value of the right to divert water from the Sierra Nevada mountains to be calculated: approximately $1.5 billion.